AGRICULTURAL
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1

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Good practice for the small-scale production of bottled coconut water

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1

Good practice for the small-scale production of bottled coconut water

by

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Agricultural and Food Engineering
Technologies Service

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Agro-Industries Division

FAO

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The Agricultural and Food Engineering Training and Resource Materials make available to public sector institutions, universities, industry associations and NGOs, materials to support capacity building related to the application of technologies for value addition in the agrifood sector and their implications for policy. The series includes training manuals and resource guides that have been developed and tested through FAO's normative and field programmes.

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Preface

Coconut water is consumed as a refreshing drink in many coconut producing regions. Growing health consciousness and consumer demand for coconut water that retains both its natural flavour and its aroma characteristics has stimulated interest in the identification of alternative technologies for preservation of the product.

Being aware of the various categories of coconut water processors in developing countries, FAO has worked collaboratively with research institutions and through Technical Cooperation Projects to develop three technology packages: a high level technology package which employs the use of microfiltration for cold sterilization of the product; a middle-level of cold preservation technology targeted for use by small and medium enterprises and an "appropriate" level of technology targeted to coconut water vendors.

This guide is designed for use as a learning resource for small and micro entrepreneurs who bottle coconut water, as well as a training resource for extension workers and trainers. It documents good practice for the application of a "middle level" of technology for the cold preservation of coconut water. The information is presented in a very simple and easy-to-follow format

It is hoped that the information provided in this guide is useful to improving the quality, shelf-life and output of bottled coconut water.

Chapter 1

Introduction

Coconut water has traditionally been consumed as a refreshing beverage in a majority of coconut producing countries. Growing consumer interest in the product both as a refreshing beverage and as a sports drink has considerably broadened its market opportunities. These growing market opportunities have, however, necessitated that coconut water be accessible in a more convenient format and have thus led to the development of technologies for the preservation and sale of the product in a bottled format.

Bottling of coconut water not only reduces the cost of bulk freighting and transportation of immature coconuts over long distances, but it enhances the shelf-life, adds value and generates income and employment for small farmers and coconut water processors.

Compositionally, coconut water is relatively high in potassium and is of a low sodium content. Its major constituents are sugars which range in concentration from 1.4 to 5 percent depending on the coconut variety and the maturity stage of the nut from which it is derived. Coconut water also contains small quantities of protein (0.7 percent) and fat (0.2 percent), as well as amino acids, vitamins and minerals.

The commercial production of canned coconut water has traditionally employed a high-temperature/short-time preservation process. The product of this process has, however, found limited consumer acceptance in coconut producing regions, owing to distortion of the delicate flavour of the product by the high temperatures applied in the process. Cold preservation is, therefore, the method of choice for extending the shelf-life of the product.

The cold preservation of coconut water essentially involves collection of the coconut water, filtration and bottling under

hygienic conditions. Various levels of bottling and filtration technologies, requiring various levels of skill and investment can be applied in the cold preservation of coconut water. The shelf-life and cost of the product are greatly influenced by the level of the processing technology.

The "all natural" image of cold-preserved bottled coconut water and the fact that it can be produced without the inclusion of additives are two winning points with consumers of the product.

This guide describes a "middle level" of cold preservation technology, for producing coconut water having a shelf-life of at least ten days under refrigerated conditions. This "middle level" of technology employs a single coarse filtration step and chilling of the product.

Chapter 2

The coconut water processing chain

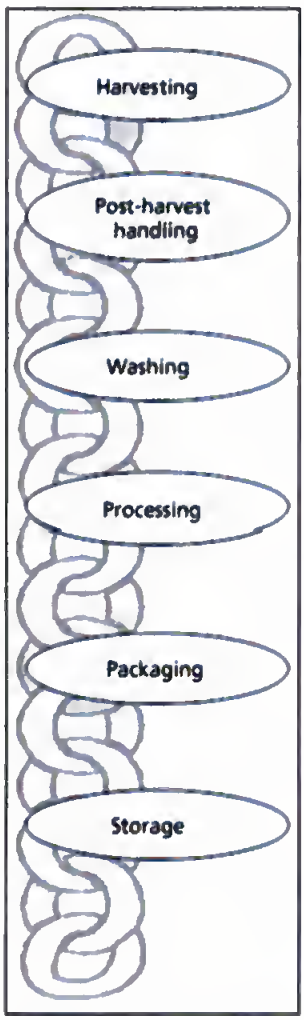

Figure 1
The cocounut water processing chain

The coconut water processing chain includes all the critical steps and processes that must be carried out in order to produce high quality coconut water. Like any chain, **the coconut water processing chain is only as strong as its weakest link.** Every stakeholder involved in coconut water processing, i.e. the harvester, those who load, unload and transport coconuts, those who cut coconuts, those who bottle and those who sell coconut water, are responsible for applying good practice to assure the quality and shelf-life of the final product.

Notes

Chapter 3

Safety and quality in coconut water bottling operations

WHAT IS QUALITY?

- Quality includes all the factors or characteristics that are used to decide whether a product is good or not.
- A product that is not of acceptable quality must not be sold since it could be **unsafe** and make the consumer ill.

WHAT ARE THE MAJOR FACTORS THAT IMPACT ON COCONUT WATER QUALITY?

Pre- and post-harvest factors as well as storage conditions can negatively impact on the quality of coconut water.

Pre-harvest factors

- **Contamination by pesticide residues**
  - These result from the use of pesticides during production of the coconut.
- **Contamination with heavy metals**
  - Heavy metals could enter coconut water through soil or water contamination and can cause illness.

Post-harvest factors

- **Contamination by microorganisms**
  - Microorganisms could enter coconut water through improper post-harvest handling and processing techniques.

BOX 1

Microorganisms

- Moulds, yeasts, bacteria and viruses are called microorganisms;
- Microorganisms live everywhere- in the air, in dirt, on our skin;
- Many microorganisms are too small to be seen with our naked eye;
- Many microorganisms are good, and play an important positive role in our lives;
- Several microorganisms cause spoilage in foods;
- Some microorganisms cause diseases. These are called *pathogens;*
- Some microorganisms can secrete poisonous materials.

How do microorganisms contribute to spoilage of coconut water?

- Microorganisms feed on the sugars in coconut water and produce acid and gas, thus causing it to ferment;
- Microorganisms contribute to breakdown of the fat present in coconut water and cause it to turn rancid;
- Microorganisms contribute to the breakdown of the small quantities of protein in coconut water, and cause it to have the smell of sulphur.

• **Storage conditions of the coconut post-harvest**

- High temperature stimulates the respiratory rate of the coconut post-harvest, leading to rapid quality deterioration of the water within the intact coconut.

• **Storage conditions of bottled coconut water**

- High temperature increases the rate of microbial growth within the bottled product, thereby reducing its shelf-life.

HOW CAN THE QUALITY AND SAFETY OF COCONUT WATER BE ASSESSED?

At home/ in the absence of a laboratory?

- By observing the appearance of the product
  - is the product clear in appearance?
  - does it appear to be fermenting (this means producing gas within the bottle)?
  - are there any foreign objects, e.g. hair, insect parts, dirt particles in the product?
- By noting the smell
  - does it smell rancid?
  - does it smell like sulphur?

In the laboratory?

- By chemical testing
  - for pesticide residues
  - for heavy metals
  - by measuring the free fatty acid content.
- By monitoring the physiochemical properties
  - measuring the pH
  - measuring the brix
  - measuring the level of turbidity (i.e. the cloudiness of the product)
- By microbiological testing
  - to determine the number of microorganisms present in a sample of the product;
  - to determine the types of microorganisms that are present.

WHAT ARE SOME QUALITY SPECIFICATIONS FOR BOTTLED COCONUT WATER?

Coconut water of good drinking quality is colorless and clear in appearance.

Specifications of an acceptable product are as follows:

Physiochemical Characteristics

pH	5 - 5.4
Brix	5 - 6.5

BOX 2
The pH

What is pH?
The pH of a product provides an indication of the level of acidity of the product and is measured on a unit scale of 0 to 14. A pH of 7 is neutral. pH values of less than seven are acidic, those greater than seven are alkaline. Coconut water has a pH of between 5 and 5.4 and is therefore slightly acidic.

How is it measured?
pH is measured with the use of a pH meter.

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Plate 1
A hand-held pH meter

Microbiological Limits

Total Aerobic Plate Count/mL	Less than 5000
Coliform / mL	Less than 10
Faecal Coliform / mL	Nil

The microbiological count (or total aerobic count) gives an indication of the wholesomeness of the product, while the coliform count gives an indication of the level of hygiene used in processing and packaging of the product. Pathogenic microorganisms such as faecal coliforms are potentially harmful to the consumer and are, therefore, not tolerated in coconut water.

BOX 3
Brix

What is Brix?
Brix provides an objective measurement of the sugar concentration in a product and hence gives an idea of the level of sweetness of the product. Brix is measured with the use of a refractometer (Plate 2)

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Plate 2
A hand-held refractometer

HOW CAN THE SAFETY AND QUALITY OF COCONUT WATER BE ASSURED?

By applying good practice in order to avoid contamination and temperature abuse at every step of the processing chain.

WHAT IS GOOD PRACTICE?

Procedures learnt from experience and verified by scientific testing.

Good practice

- is science based;
- is constantly being improved;
- is cost-effective;
- ensures the production of safe high quality products.

Notes

Chapter 4

Coconut water processing: a chain approach

Coconut water within the nut is sterile. This means that it is free from microorganisms. Whenever exposed to the air, or to the external environment, the product is subject to microbiological contamination and deterioration. Proper handling and temperature management throughout the post-harvest and processing chain are essential to allowing coconut water to retain its inherent qualities prior to processing. Proper sanitation management throughout the chain is also critical to assuring the quality, safety and shelf-life of the bottled product.

Key considerations and good practice to be implemented at each step of the processing chain are now described.

PRE-HARVEST SELECTION OF COCONUTS FOR COCONUT WATER PROCESSING

Key considerations

Varietal selection and stage of maturity

The volume of coconut water that can be recovered from a coconut varies in accordance with the coconut variety and the level of maturity of the coconut. Coconuts of the Maypan variety, for example, yield larger volumes of coconut water than do Yellow Dwarf, Green Dwarf or Orange Dwarf varieties (Figure 2). Maximum yields of coconut water are, however, consistently obtained from 9-month old coconuts (Figure 2).

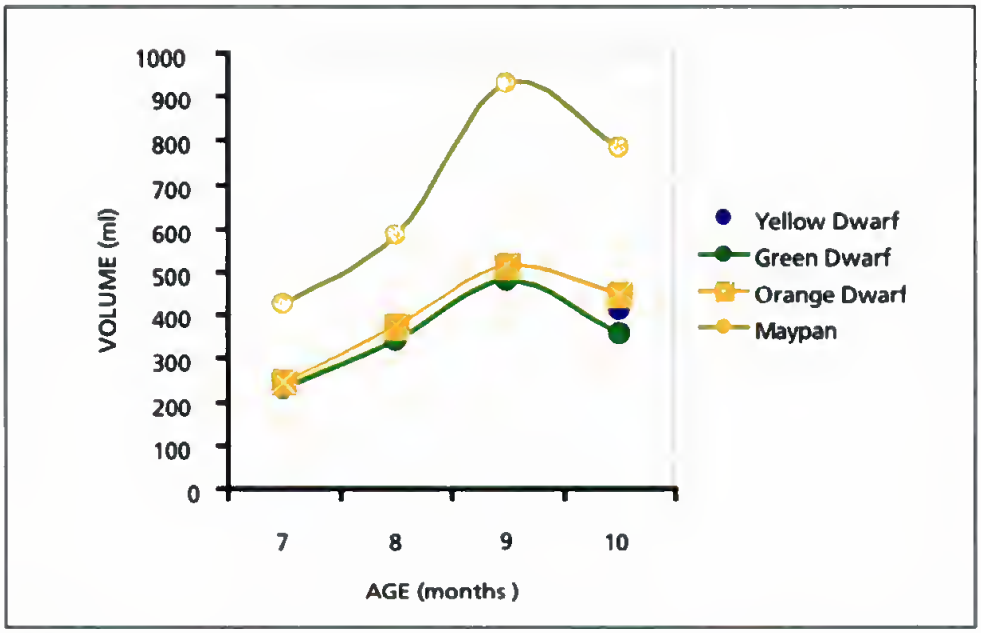

Figure 2
Profile of changes in the volume of coconut water at different stages of maturity for four coconut varieties.

Good practice

Coconuts must be **harvested at 9 months of maturity.**
- to obtain the maximum volumes of water.

HARVESTING

Key considerations

Time of harvest

Coconuts are living materials and are consequently actively respiring or breathing even after harvest. The higher the temperature of a coconut at harvest, the more rapidly will it continue to respire in the post-harvest phase and the more rapidly will its constituents undergo physiological changes, leading to deterioration.

Method of harvest

Coconuts should never be allowed to fall to the ground during harvesting as this could lead to mechanical injury and facilitate the entry of microorganisms which cause spoilage of the coconut water within the coconut.

Studies conducted at the University of the West Indies show that coconut water collected from coconuts which had cracked when dropped from a height of 8 metres, was cloudy (low % transmittance) as opposed to being clear in appearance and had a low pH (Figure 3), both of which are indications of spoilage of the product. Similarly, coconut water collected from dropped and cracked coconuts had a higher free fatty acid content, than that collected from coconuts that were dropped and intact and those that were hand picked.

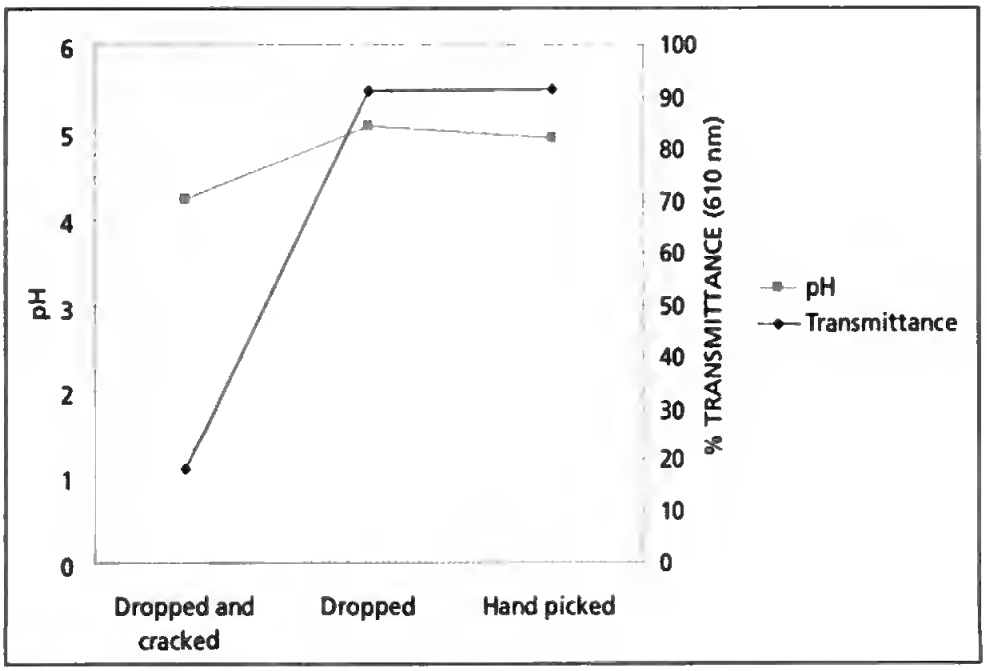

Figure 3
Comparison of the pH and level of turbidity (% transmittance) of coconut water collected from coconuts which had dropped and cracked compared to coconuts that were intact and hand-picked.

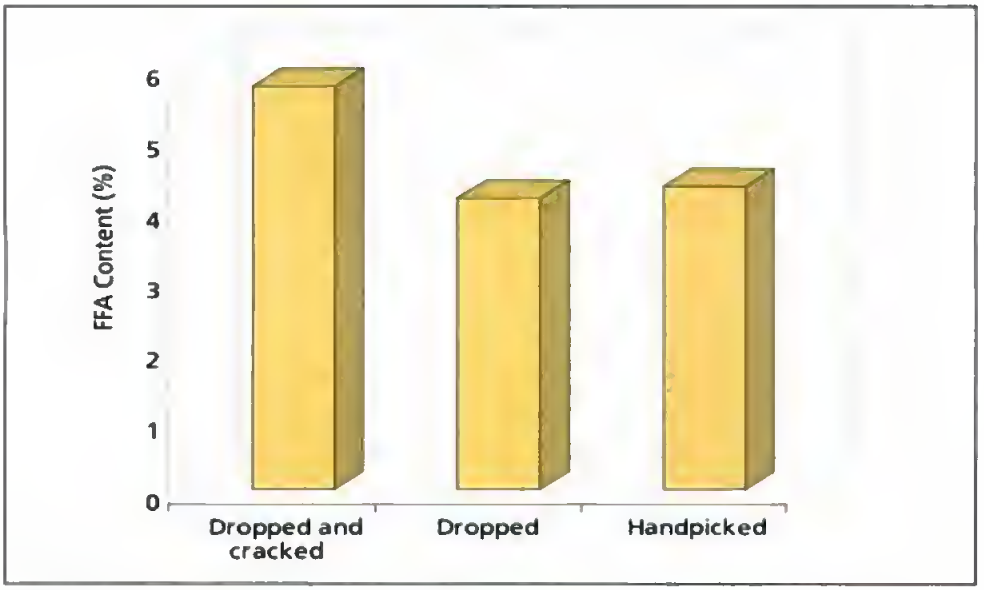

Figure 4
Comparison of the level of free fatty acids (% FFA) in coconut water collected from coconuts which had dropped and cracked compared to coconuts that were intact and hand-picked.

Good practice

- Harvest coconuts that are in sound condition (i.e. coconuts that are intact) during the earlier/cooler part of the day.
- Lower coconut bunches to the ground with the use of a rope. Coconut bunches should **never** be dropped to the ground.

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Plate 3
Lowering a bunch of coconuts with a rope

POST-HARVEST HANDLING

Key considerations

Potential for contamination of the coconut
Harvested coconuts should never be allowed to come into contact with extraneous matter such as soil and chemical fertilizers, since if not properly washed off, these extraneous materials increase the risk of chemical and microbiological contamination during coconut water collection.

Mechanical injury
Coconuts are highly susceptible to mechanical damage during handling (loading and unloading) and transportation. Care must, therefore, be taken to avoid cracking during handling and transportation.

Storage conditions
Harvested coconuts are actively respiring. This respiratory activity leads to changes in the chemical composition of coconut water within the intact coconut. Every effort must, therefore, be made to ensure that respiratory processes are slowed through

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Plate 4
Unloading coconut bunches from a truck

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Plate 5
Storage of coconut bunches on racks in a shaded area

proper temperature control and that the coconut water is processed within the shortest possible time-frame after harvest.

Good practice

- At all times, harvested coconuts must be in contact with clean surfaces and should not be allowed to come into contact with soil or chemical agents. They are best stored in a clean, well-ventilated area, off the ground (on a rack) and away from direct sunlight.
- Coconut water should be collected from the harvested coconut within 24 hours of harvest.
- Coconuts must be loaded in a manner which prevents them from rolling about and hence cracking during transportation. They must be handled (never dropped) with care during unloading in order to prevent cracking.

QUALITY INSPECTION OF HARVESTED COCONUTS

Key considerations

Maturity and soundness of coconuts
Only good coconuts of the correct developmental stage (9 months), which are in sound condition, must be used as sources of coconut water for bottling.

Good practice

Poor quality nuts must be rejected. These include:

- nuts with cracks;
- nuts that are either pre-mature or over-mature;
- nuts with contents that are cloudy (i.e. exhibit a high level of turbidity);
- nuts with contents having a rancid odor.

WASHING THE COCONUTS

Key considerations

Reducing the level of contamination

Washing in potable water and removal of soil are very critical to reducing the risk of transferring contamination during the collection of coconut water.

Sanitization of the washed coconuts, which involves soaking the coconuts in a dilute bleach solution, further, reduces the number of microorganisms on the surface of the coconut.

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Plate 6
Washing coconuts

Good practice

- Wash the coconuts in potable water to remove dirt, debris or any form of contamination from the surface of the nut. Brush the coconuts during washing in order to thoroughly remove dirt that is difficult to remove.
- Examine the coconuts during washing and discard damaged or immature coconuts.
  - Change the wash water frequently- at least once per hour or more frequently if there is a high level of soil contamination on the coconuts.
- Transfer the water-washed coconuts into a sanitizing solution[1] for at least 15 minutes.
- Transfer the sanitized coconuts to a clean surface off the ground and allow to air dry.

SANITIZATION OF TOOLS AND IMPLEMENTS FOR PROCESSING

Key considerations

Reducing the risk of microbial contamination
All tools and implements must be properly cleaned, sanitized and air-dried in order to reduce the risk of microbial contamination during processing operations.

Good practice

- Wash all tools and implements including the chopping board, the cutlass, funnels, strainers, etc., with soap and potable water.
- Transfer to sanitizer[1] for 15 minutes, or transfer to boiling water for 15 minutes.
- Allow all implements to air dry in a clean environment (away from flies).

[1] Sanitizing solution: 1 tablespoon bleach per 4.5 litres of water.

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Plate 7
Teflon cutting board and stainless steel cutlass used for cutting coconuts

- Wash filter cloths with soap in potable water to remove any dirt, debris or other unwanted material.
  - Do not wash filter cloths together with personal clothing items.
- Thoroughly rinse filter cloths in potable water in order to remove any traces of soap.
- Transfer to sanitizer[2] for 15 minutes, or transfer to boiling water for 15 minutes.
- Dry in a clean oven or dryer at 100°C.
- Store sanitized filter cloths in a sanitized, dry and covered container.
  - The cloths are to be sanitized or re-sanitized if not used until the following day.

SANITIZATION OF BOTTLES AND CAPS

Key considerations

Reducing the risk of contamination
Poorly and un-sanitized bottles are a source of contamination and greatly compromise the shelf-life of the product.

[2] Sanitizer: a solution consisting of 1 tablespoon of bleach per 4.5 litres of water.

Good practice

All bottles and caps must be sanitized.

- Rinse the bottles and caps in potable water.
- Sanitize for 15 minutes.
- Allow the bottles and caps to air dry in the inverted position.
  - Drain racks may be used for this purpose.

COCONUT WATER BOTTLING

Key considerations

Observance of good hygienic practice

Human and environmental contamination of coconut water must be avoided at all costs. All individuals involved in the cutting of coconuts and with the coconut water bottling process must be in good health and must observe Good Hygienic Practices (GHP; see below) in order not to contaminate the product during coconut water collection and bottling.

Good manufacturing practice in the processing environment

The environment in which coconut water is bottled must be clean and free of animals, insects, dust or garbage. All surfaces that are likely to come in contact with coconut water must be properly cleaned and sanitized. The area in which the coconuts are cut must be physically separated from the bottling area. Waste material (i.e. coconut husk) must be removed from the processing environment and promptly be disposed of.

Temperature control during processing

Cooling of the coconut water to 4°C immediately after collection slows down the onset of degradative processes. Where large volumes of coconut water are to be bottled, the use of a refrigerated cooling tank for rapid cooling is highly

recommended. Coconut water retains its quality characteristics under conditions of low temperature (0°C) storage (Figure 5). The product however undergoes spoilage at higher temperatures, evidenced by declining pH and brix during storage at 26°C over one week (Figure 5).

Good hygienic practices for coconut cutters and coconut water bottlers

Persons working in the production of bottled coconut water must observe good hygienic practice. In so doing, they must:

- Wash their hands prior to engaging in any operations associated with coconut water processing.
- Not eat, chew gum, talk or smoke while working.
- Wear clean clothes or aprons when handling the coconut water.
- Not handle coconuts or coconut water if they are sick (e.g. with the "flu").
- Clean and cover cuts with appropriate bandages and wear gloves when handling coconuts or coconut water.
- Cover all hair (including beard) to protect the coconut water from possible contamination by hair.

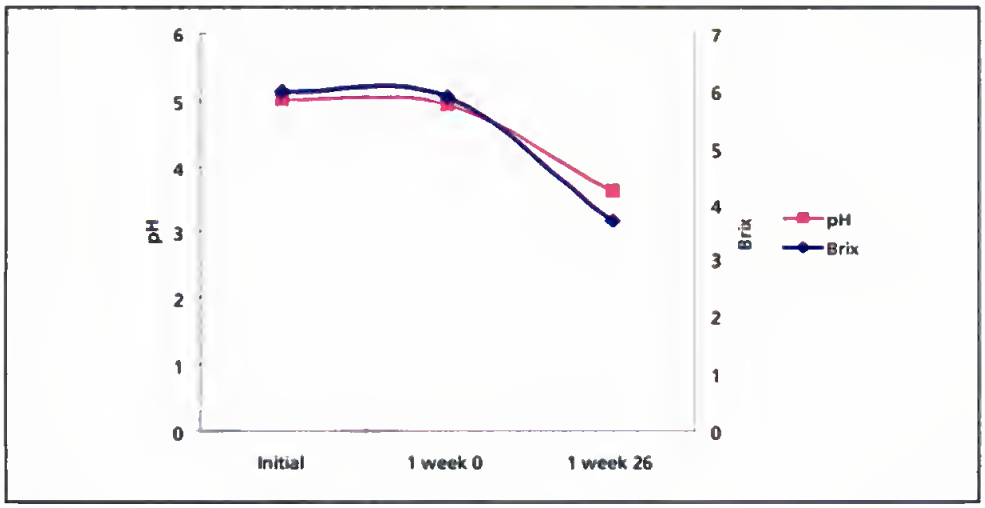

Figure 5
Changes in the pH and brix of bottled coconut water samples as compared to the original sample after storage at 0°C and 26°C for 1 week

Good practice for coconut water collection

- Have a spare stainless steel cutlass and cutting board, sanitized at all times.
- Change and sanitize the cutlass every hour.
- Change the filter cloth every ½ hour.
- Change and sanitize the cutting board every hour.
- Cut the coconuts on the cutting board using a sanitized stainless steel cutlass.
- Discard any coconuts with a foul odor or that seem doubtful.

Good practice for the filtration of coconut water

- Coarse filter the coconut water by decanting it into a sanitized container equipped with a strainer lined with sanitized silk screen cloth or cheese cloth.
- Promptly transfer the filtered coconut water to a cooling tank and cool to 4°C, or rapidly cool by transferring to a freezer for 3-4 hours.

Good practice for the bottling of coconut water

- Rapidly bottle and seal the cooled (4°C) coconut water in pre-labelled bottles, and immediately transfer to a chiller maintained at 4°C .
- Observe good hygienic practice during bottling in order to avoid human contamination.

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Plate 8
Stainless-steel coconut water collection container equipped with a strainer and lined with cheese cloth

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Plate 9
Cooling tank

LABELING OF BOTTLED COCONUT WATER

Labels facilitate product identification and product traceability. They must be both attractive and informative.

- Labels must contain the following information:
  - The name of the product and the Brand name.
  - The net volume of coconut water.
  - Ingredients in descending order of quantity.
  - The manufacturer's name and address.
  - A "best used before" date.
  - A "Keep Refrigerated" statement.
  - A code date indicating the date of manufacture.

Good practice

- Water proof labels must be used on bottled coconut water in order to assure their adherence to the product during storage on ice and during refrigeration.

STORAGE AND TRANSPORTATION OF BOTTLED COCONUT WATER

Key considerations

Bacteria and yeasts are the predominant microorganisms associated with freshly bottled coconut water. These microorganisms multiply at a rapid rate at elevated temperatures and contribute to spoilage of the product. It is, therefore, critical that the temperature of bottled coconut water be maintained between 0-4°C during transportation and storage in order to assure its keeping quality and to enhance its shelf-life.

Good practice

- Refrigerate coconut water immediately after bottling.
- Store bottled coconut water at 4°C, away from light.
- Keep bottles of coconut water on ice during distribution. Never allow the temperature to exceed 4°C.
- **Monitor retail outlets to ensure that the bottled coconut water is stored at the correct temperature and away from direct light.**

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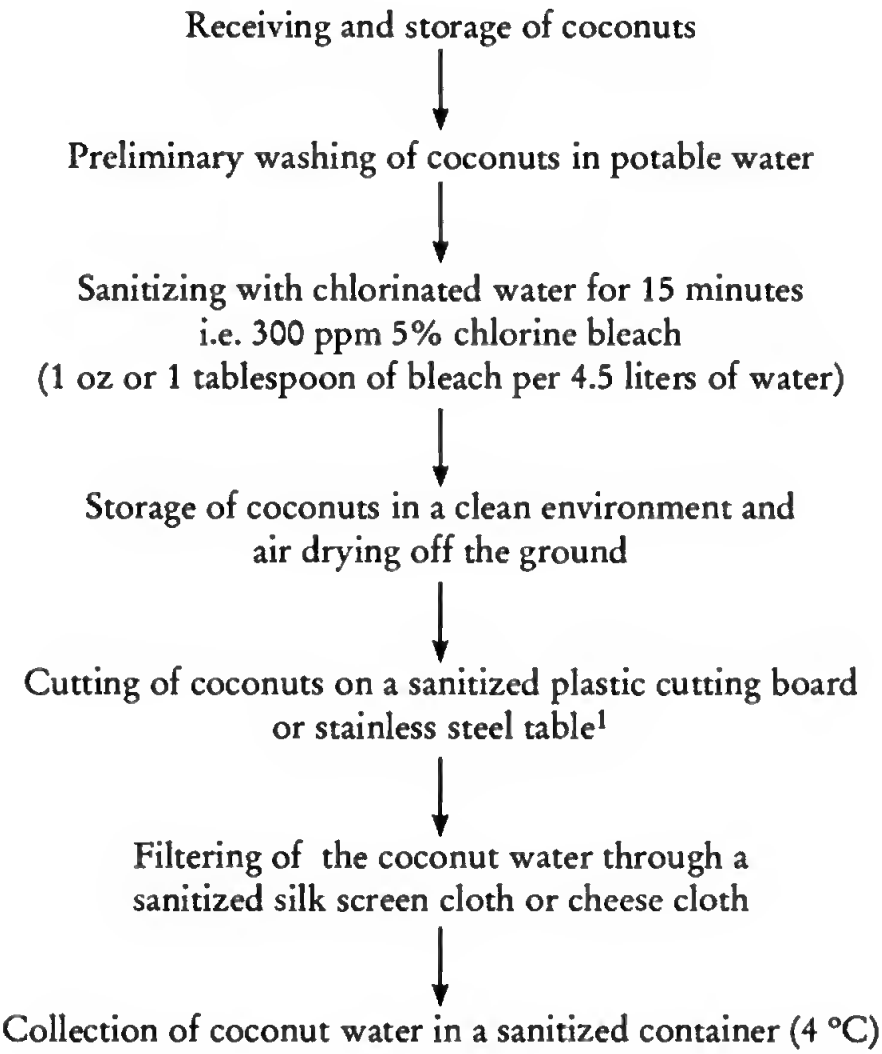
Plate 10
Cooling of bottled coconut water in a freezer

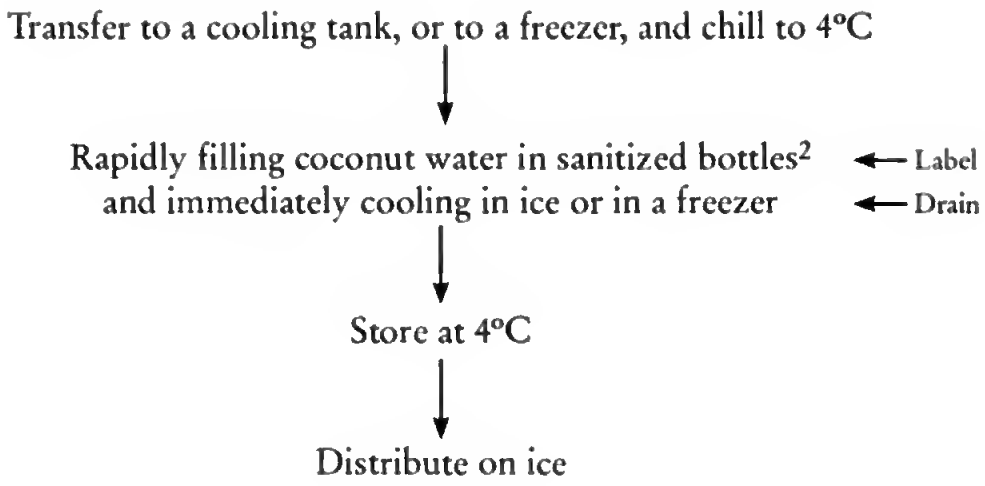
Notes

Chapter 5

Flow diagram for bottled coconut water production



[1] Quality control checks on coconut water:
a) turbidity = not turbid; b) no rancid odor.



[2] Sanitize bottles in diluted bleach water (1 tablespoon 5 percent bleach in 4.5 litres of water).

Notes

Chapter 6

Summary

GOOD PRACTICES or procedures that must be followed by the small processor for the production of high quality bottled coconut water are summarized in Table 1.

TABLE 1: Good practices for the production of high quality coconut water

Recommended practices	Reasons/Comments
1. Select 9 month-old coconuts.	Control the consistency of taste and collect the maximum volume of coconut water.
2. Do not allow coconuts to fall to the ground when picking. Nuts should be harvested and lowered to the ground.	To avoid cracking of the nuts and spoilage of the water.
3. Nuts should not be allowed to come in contact with soil, and must always be in contact with clean surfaces.	To avoid contamination of the nuts and eventual contamination of the coconut water.
4. Harvest and transport the nuts during the cooler parts of the day (early in the mornings or in the late afternoons).	To maintain optimum quality of the coconuts and water.
5. The nuts should be randomly inspected for signs of damage e.g. crack, bruises and damaged nuts should be discarded.	To assure soundness of nuts and to detect damaged nuts.
6. The nuts must be stored in a clean, well ventilated and shaded environment.	To minimize contamination and to prevent spoilage.
7. The nuts must be washed in potable water, followed by a mild bleach solution.	To remove dirt, debris and reduce the microbial load on the surface of the nuts.
8. The wash water must be frequently changed.	To avoid a build up of dirt and microorganisms and possible re-contamination of the nuts.
9. Stainless steel cutlasses, must be used for cutting open the nuts.	To avoid metallic contamination of the water.
10. The opened nuts must be checked for cracks or signs of spoilage.	To detect and discard spoilt nuts.

Recommended practices	Reasons/Comments
11. The coconut water must be filtered into a sterilized glass or stainless steel container.	To remove undesirable particles, such as fibre and pieces of shell, and to minimize product contamination.
12. The coconut water must be rapidly cooled to 4°C.	To slow microbial growth and enzymatic reactions.
13. Fill coconut water into sanitized bottles and immediately cool to 4°C.	To slow microbial growth and enzymatic reactions.
14. Transfer cooled bottles of coconut water to chilled storage and maintain at about 4°C.	To slow microbial growth and enzymatic reactions.
16. Keep bottles of coconut water on ice (0-4°C) during distribution.	To maintain the quality of the bottled coconut water.
17. Monitor retail outlets to ensure that product is stored at the correct temperature. • Temperatures not exceeding 4°C.	To maintain the quality of the product during display at points of retail sale.

Notes

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Good practice for the small-scale production of bottled coconut water

Nature provides an ideal sterile package for coconut water in the form of the intact coconut. However, on cutting through the coconut, the coconut water is exposed to the elements and rapidly deteriorates. Application of the cold preservation process described in this guide can slow this rapid deterioration while preserving the delicate flavour of the product. In this manner bottled coconut water, when stored at 0°-4° C, can have a shelf-life of 10 days to three weeks.

This guide is designed to serve as a learning resource for micro and small-scale enterprises which bottle coconut water as well as a training resource for extension agents and trainers.

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